EAG CAPABILITIES OVERVIEW

Engineering Sciences
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General Manager

NASA Goddard
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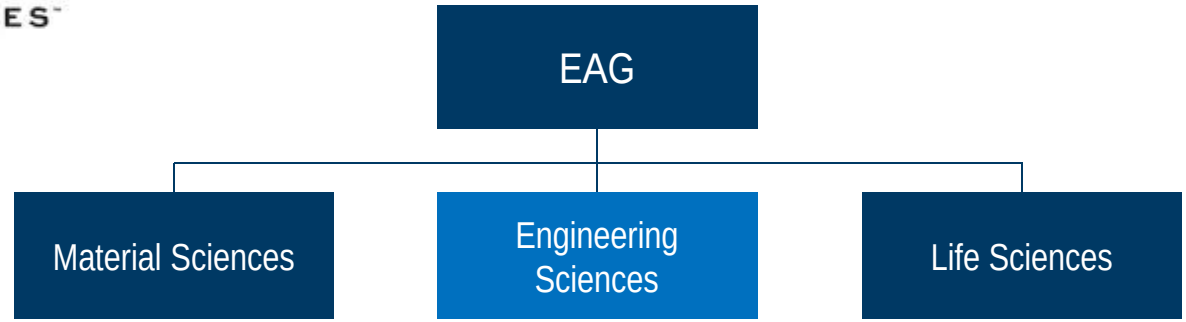
EAG LABORATORIES | WE KNOW HOW™

OVERVIEW OF EAG LABORATORIES



- EAG Laboratories Divisions:
  - **Engineering Sciences ("ES"):** Global leader in production and engineering outsourced testing in Electrical, Reliability Stress, and Physical failure analysis services for technology customers
  - **Material Sciences ("MS"):** Global leader in micro-analytical surface testing and analysis of materials – started as Charles Evans & Associates in 1978
  - **Life Sciences ("LS"):** Global leader focused on technical analyses and registration requirements for the Agrochemical, Industrial Chemical, Pharmaceutical and Animal Health Industries

- EAG Laboratories is a differentiated testing and evaluation company which has a common thread across various technology and analytical services that serve different varied markets
- EAG Laboratories serves over 5,500 customers across a broad array of industries including: commercial, industrial, automotive, lighting, aerospace, LEDS, solar, biomed, pharma, chemical, agrochemical, industrial chemical, consumer and technology end markets
- >1,250 highly skilled employees worldwide, including >100 PhD scientists

ENGINEERING SERVICES

- **Electrical Product Testing, Characterization and Evaluation with ATE development for volume, pilot, prototype and characterization**
- **Reliability Stress Testing, Qualification, Monitoring and Burn-in**
- **ESD and Latch-up Testing**
- **FIB Circuit Edit and Debug**
- **Full Failure Analysis Capability**
- **Materials Analysis**
- **Printed Circuit Board (PCB) Design and Hardware fabrication**

We provide an integrated model that supports semiconductor / microelectronics companies in the total product lifecycle from conception to volume production

§ More than 30 years of **experience** in electronics industry
§ Over $100M in **capital** equipment investment
§ **Quality Systems**: ISO-9001 Registered, DLA Mil-883 Suitable, ISO-17025 Accredited, ITAR Registered, and Automotive compliant with ISO/TS-16949

THE EAG APPROACH

- Engineering expertise
  - Over 20 years of history providing microelectronics services with highly skilled staff
  - Established processes and methodology to identify root cause and deliver consistent high quality results and services
- Large, comprehensive equipment set for increased scalability and flexibility
  - Enables us to pick the right tool set / platform and location for the job
  - Parallel processing of large projects; scalable to handle fluctuations in demand
  - System redundancy to minimize impact
  - Capability to analyse systems down to the component level
- Multidisciplinary approach with all services under one roof
  + Single point of contact +“Turn-Key” offering Start-Finish

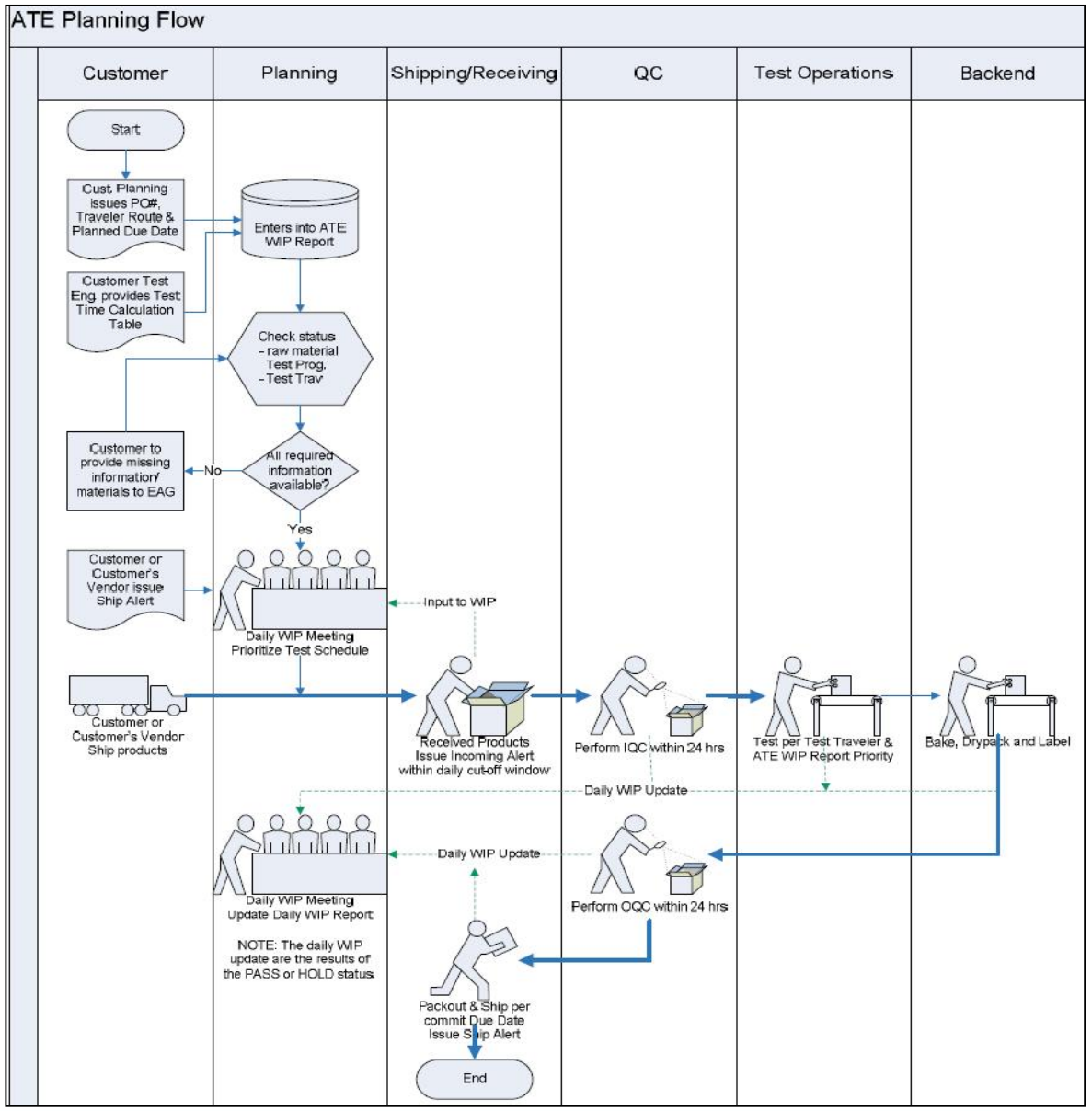
EAG Laboratories solution focus allows us to assemble the right combination of resources to deliver optimized solutions that are timely and cost effective thereby reducing risk

ELECTRONIC TEST & MEASUREMENT (ATE)

- Production/Pilot/Prototype Testing
- Hardware Design / Fabrication
- Test System Rental (On site/Remote Log in)
  - 24/7 access to testing and facilities
  - EAG engineers and expertise available on-site
  - System maintenance and support from in-house staff
- Test Program Development / Test Engineering
- Program transfer to leading OSATs offshore
- Product/Process Characterization

ATE PRODUCTION SERVICES

- Flexible production flow includes:
  - Daily WIP planning
  - Incoming Quality inspection
  - Production test
  - Bake, dry pack, label
  - Outgoing Quality inspection
  - Drop/Direct shipments
- WIP system for visibility



RELIABILITY STRESS TESTING SERVICES

Operating/Storage Life Test

- High-power Operating Life
- High Temperature Operating Life
- Low Temperature Operating Life
- High/Low Temperature Storage

Temperature/Humidity Stress

- Highly Accelerated Stress Test (HAST)
- Temperature Humidity Biased
- Temperature / Humidity
- Temperature and Humidity Cycling

Broad set of equipment

- MCC HPB-5B, 128 I/O, 32M vectors
- INCAL INFINITY, 160 I/O, 16M vectors,
- AEHR Max III, 96 I/O, 4M vectors
- INCAL MPU, 48 I/O, 1M vectors
- CRITERIA, 48 I/O, 2M vectors

RELIABILITY STRESS TESTING SERVICES

Temperature Cycling

- Temperature Cycling (Air to Air)
- Powered Temperature Cycling
- Thermal Shock (Liquid to Liquid)

Accelerated Moisture Stress

- Highly Accelerated Stress Test
  (Biased or Unbiased)
- Autoclave up to 35 psi

Other Stresses

- Package Moisture Sensitivity Characterization
- Preconditioning Flow (MSL 1-6)
- Solder Reflow Simulation
- Gate Leakage Test



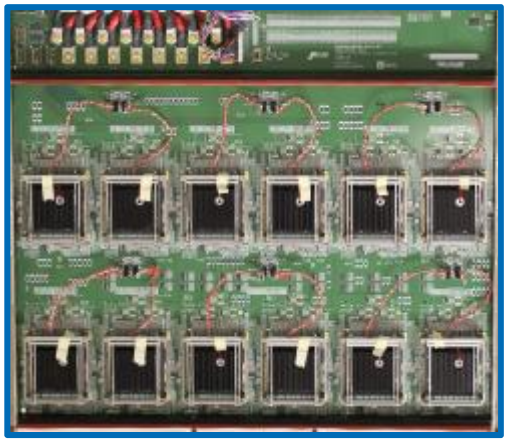


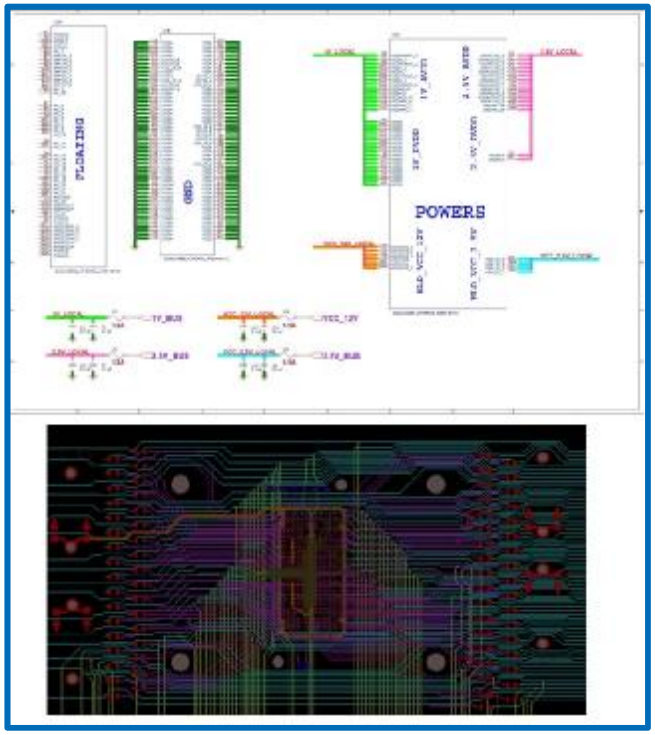

ESD & LATCH-UP CAPABILITIES

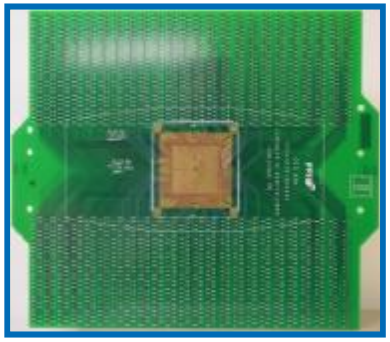
- Testing up to 2,304 Pins
- Full Characterization Reports
- ESD Human Body Model
- ESD Machine Model
- ESD Charged Device Model
- Latch-up Testing To 256K Vectors
- Temperature Forcing
- Curve Comparisons
- Multiple Systems / Multiple Locations
- Talented ESD Engineering Staff
- Adapter Boards for all platforms

IN-HOUSE PCB DESIGN

- All design work done by EAG engineering staff
- HTOL, THB, HAST, ESD, ATE designs
- Multiple board design/chamber options:
  - MCC
  - Infinity (HX, XP160)
  - Criteria
  - MPU
  - Trio-Tech / Hirayama
  - MK4
- Layout/Schematic capture
- PCB pitches down to 0.3mm
- Performance/Impedance matching

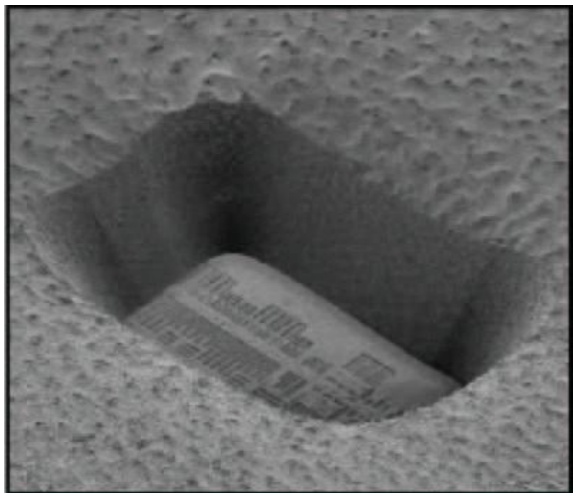


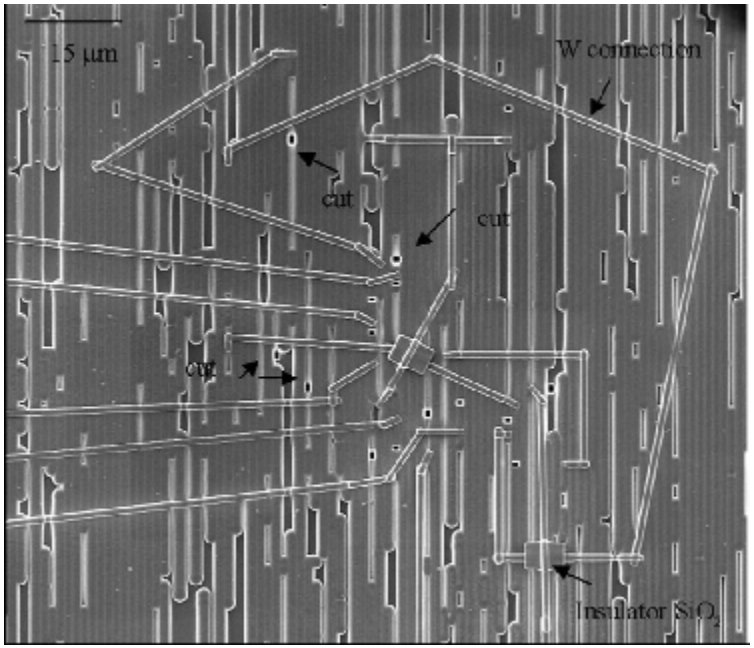




FIB CIRCUIT EDIT

- Design Debug
- Verify Functionality
- Same day prototypes for customers / engineering
- Probe points / Pads
- CAD Navigation / Overlay
- Backside FIB / Sample Prep
- Nanomachining





FAILURE ANALYSIS – EXAMPLES

- Smart meters
- Power adaptors
- Safety latch mechanism
- LED assemblies
- AC/DC converters
- Temperature pressure sensor
- Cochlear implant
- Surgical instrument controller
- Touch panel display
- Fingerprint sensor
- Car steering sensor assembly

FAILURE ANALYSIS – ORIGINS

Design, Debug, R&D

- **New product / design**
- **Package assembly**
- **Performance and function**

Production

- **Wafer sort yield**
- **IC Final test yield**
- **Yield improvement**

Qualification

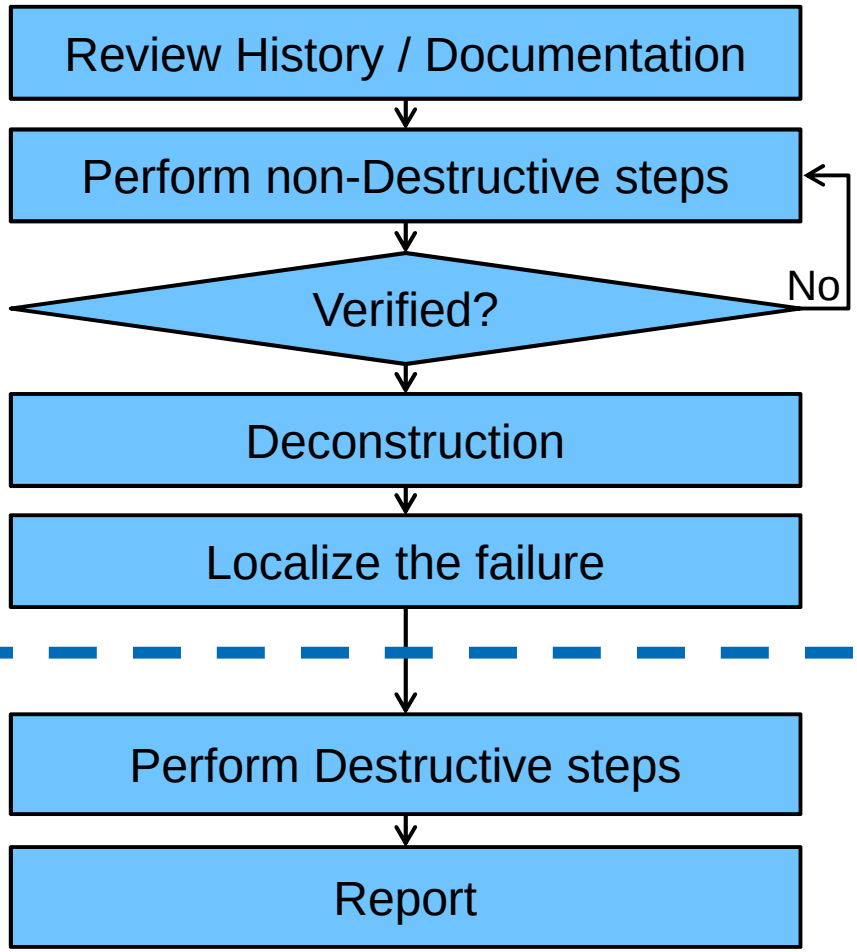
- **ESD / Latch-up**
- **Operating Life/HALT/HAST**
- **Environmental Stress**

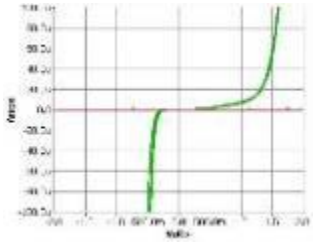
Applications

- **System Level**
- **PCB Manufacturing Yield**
- **Field Failures**

Broad analysis range from design through production and field returns

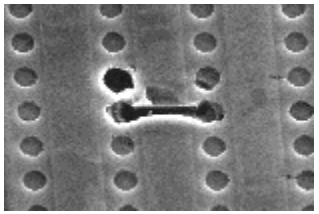
FAILURE ANALYSIS - FLOW





Electrical FA

Steps to characterize the failure and localize to a smaller area on the sample.

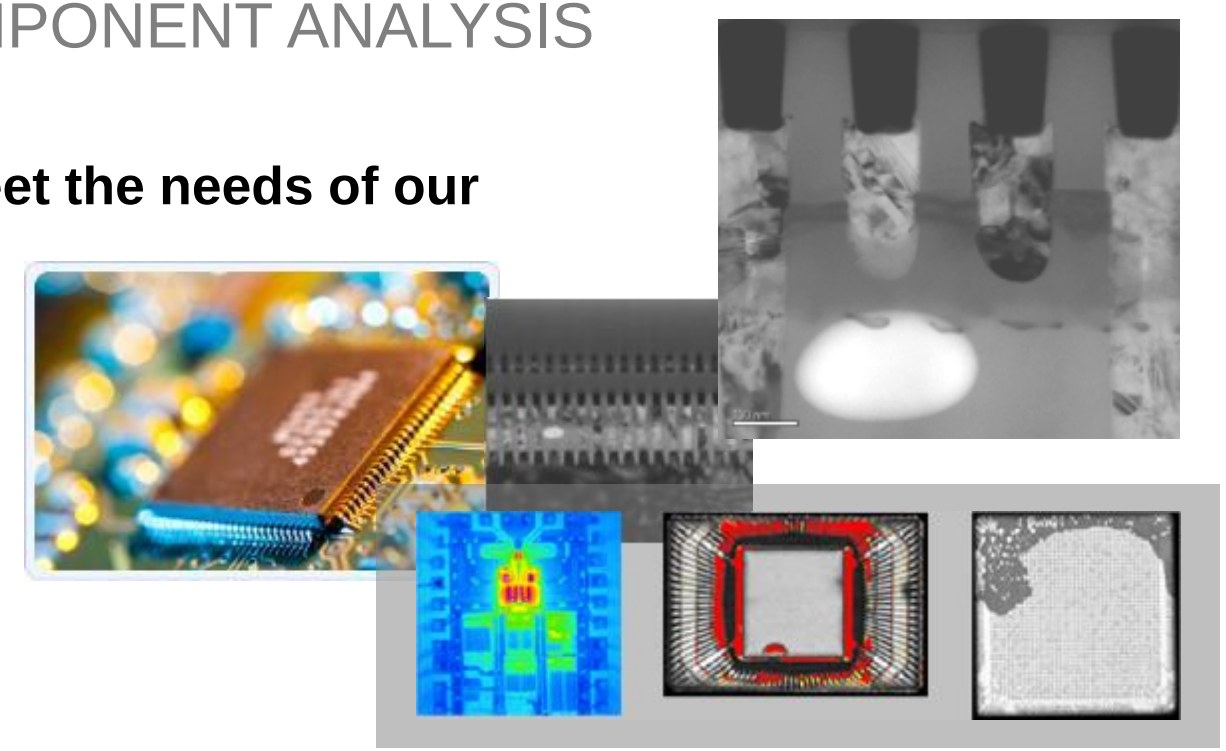


Physical FA

Dis-assembly of the sample to get a picture of the failure site / mechanism.

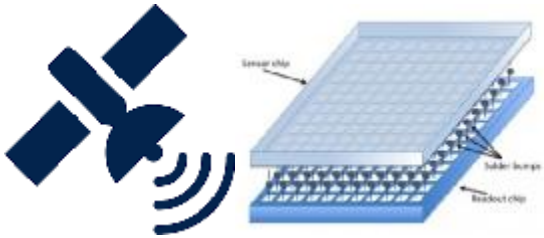
COMPONENT ANALYSIS

- **Levels of Service to meet the needs of our customers**
- **Analytical Services**
  - Individual / Client driven/directed
    - Turnkey FA
      - Level 1 – Package / Die level
      - Level 2 – Electrical Localization
      - Level 3 – Physical root cause
  - Advanced FA
    - Ø System Level
    - Ø Root Cause



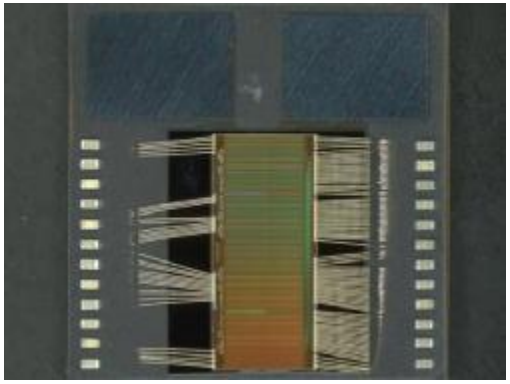
- **Capabilities and Techniques**
  - Electrical Verification / Test
  - Time Domain Reflectometry
  - X-Ray
  - SAM
  - Decap / De-lid / Sample prep
  - Deprocess / Cross section
  - Backside Analysis
  - Emmi/Light Emission Microscopy
  - XIVA / OBIRCH
  - IR Thermography
  - Dual Beam FIB / SEM / EDS
  - TEM / EDS / EELS
  - Material Analysis / Characterization

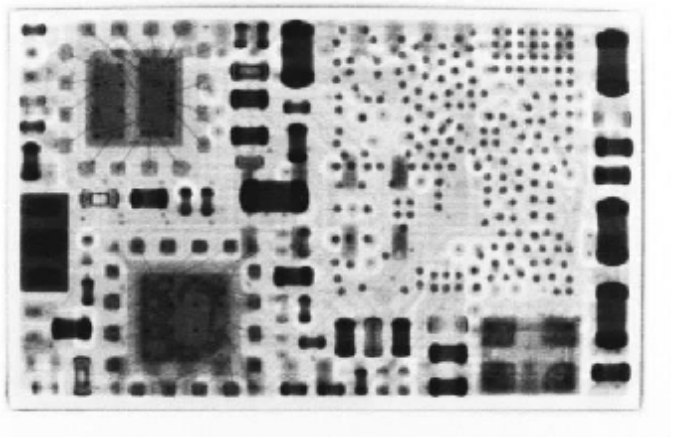
EAG LABORATORIES

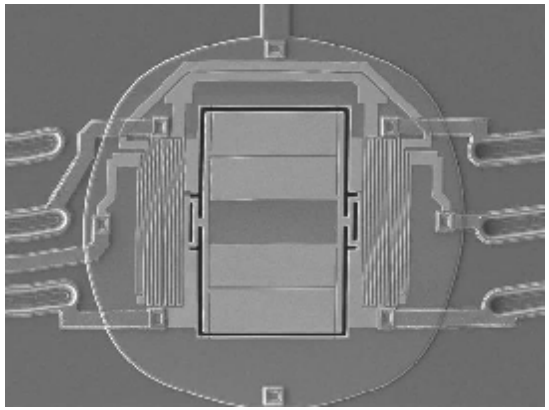


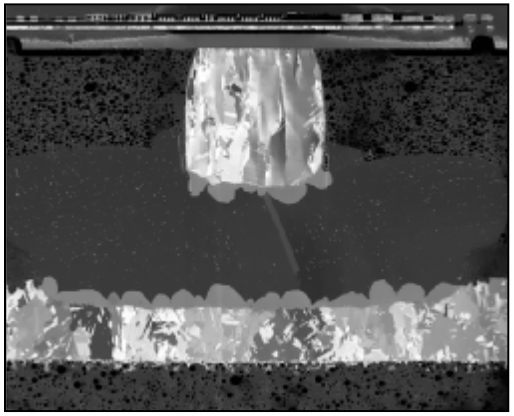
§ **Advanced Device and Sample Types**

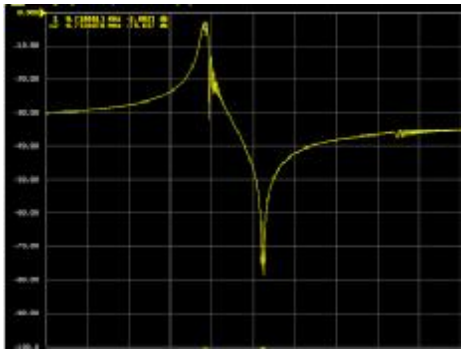
- Imaging/sensors: Read Output Integrated Circuit (ROIC), Pixel Array Detector (PDA), Focal Plane Array (FPA)
- Application Specific Integrated Circuit (ASIC)
- Custom Hybrid Assemblies
- Technology: SiGe, GaAs, InSb, InP, InGaAs, SiC, GaN
- Process nodes: 28nm, 14nm FinFET
- Package: Cu wire bond, Cu pillar, WLCSP, SoC, PoP, MCM, MEMS, 3D, Stacked Devices

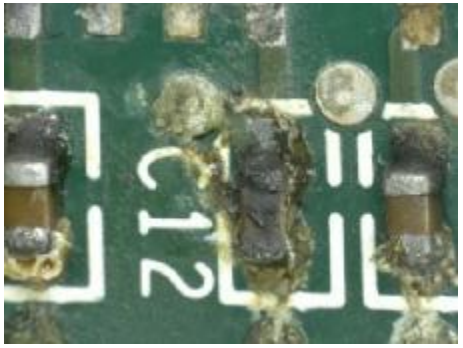




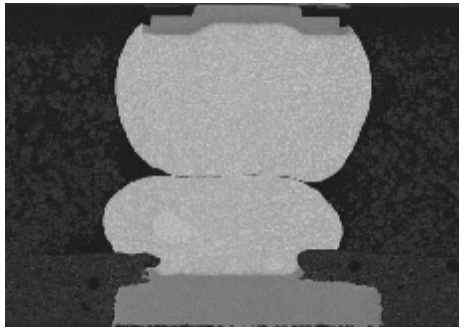


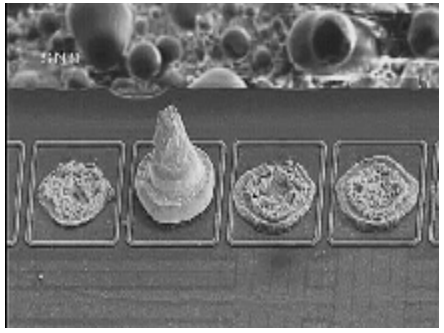


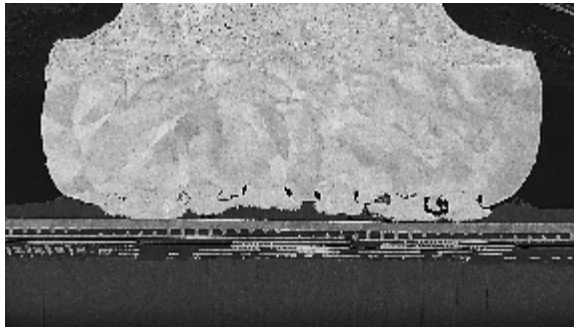


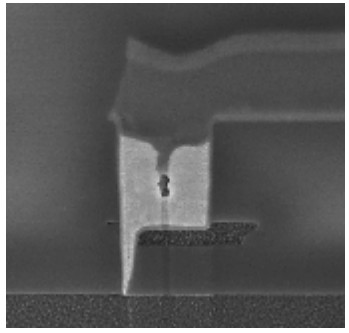


- **Failure Modes and Mechanisms**
  - Functional, parametric, high leakage, excessive sleep current, Vt shifts, dead pixels
  - Intermittent: manufacturing, application or environmental factors
  - Fabrication: silicon crystalline, metal puddling, photoresist/masking, misalignment, spacing, particles
  - Packaging and assembly: handling, contamination,









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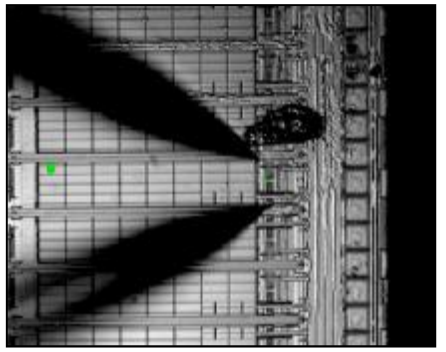
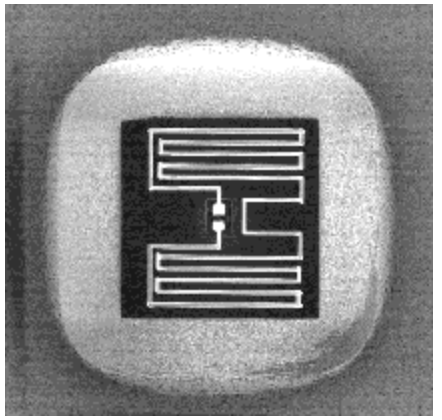
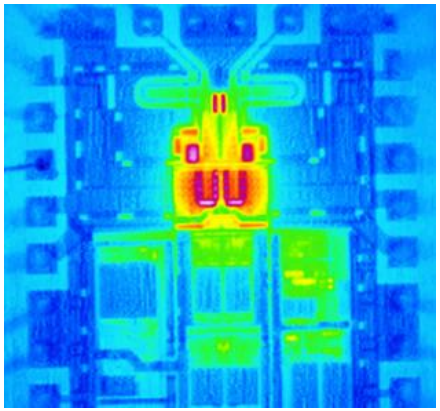
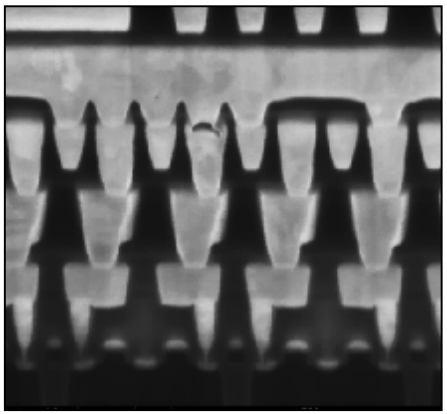


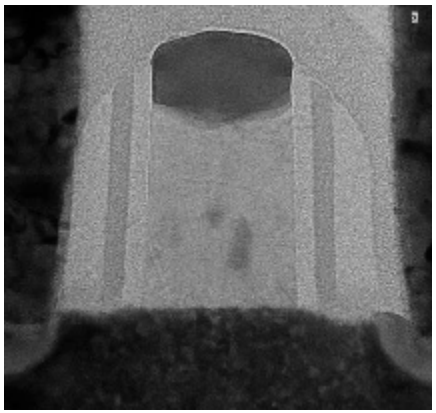


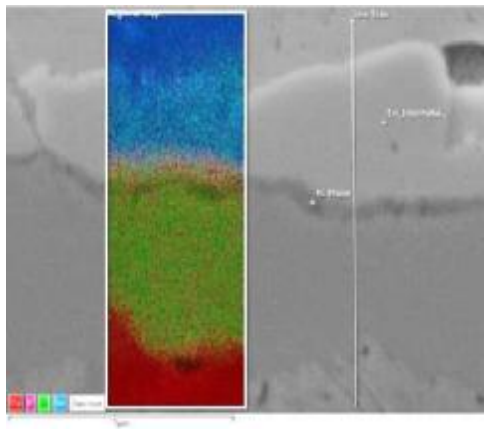
§ Advanced Analytical Techniques

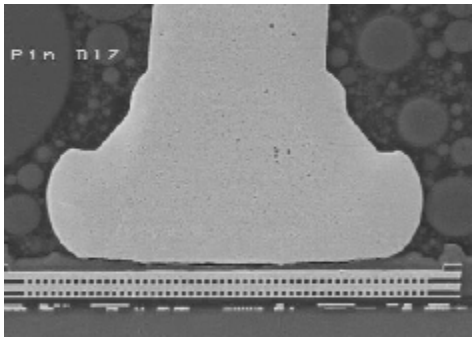
- CAD Navigation / GDS file (layout and coordinates)
- Dual Beam (DB FIB) slice and view
- Deprocessing: advanced technology nodes (Cu, low K)
- FIB Circuit Edit: probe internal nodes, modify circuit
- Advanced fault isolation tools: Photon emission (PEM/LEM/EMMI), IR thermography, Laser Signal Injection Microscopy (OBIRCH/XIVA/TIVA/LIVA).
- Backside Analysis: improved resolution, no metal masking on multi-metal layer device.)
- EDS (spot, line scan, dot mapping)
- TEM





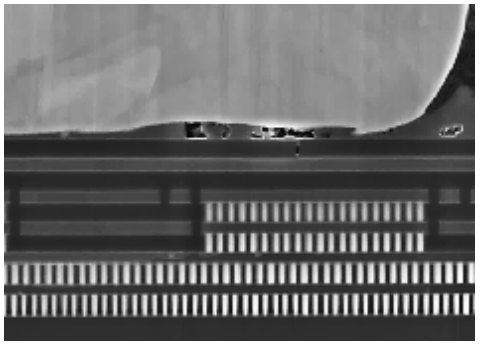


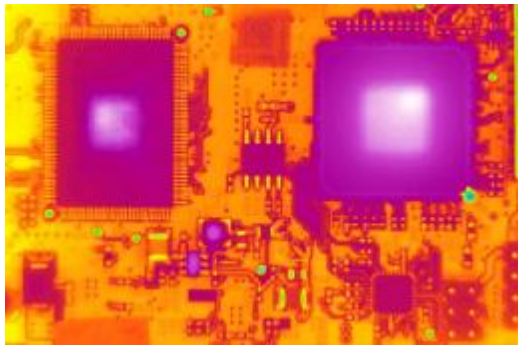


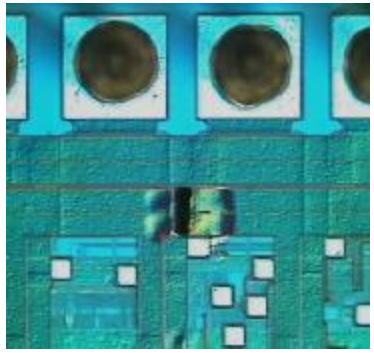


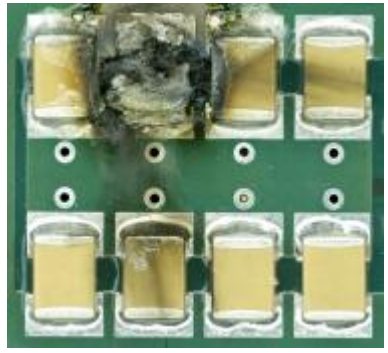
§ Investigations

- Cu wire bonded PED Qualification: AEC Q006
- Materials analysis: multi-discipline investigation, critical aspect of advanced IC analysis
- DOE: design of experiments (e.g. ESD, Reliability stress, bench test failure replication, latency defects)
- Modules and System or PCBA level
- ESD vs. EOS
- Root Cause identification: containment/corrective actions









WHY WORK WITH EAG?

- **Engineering Expertise** from system level to component level with the latest technologies to address both electrical and materials characterization

- **Customized Solutions** that can be designed to meet your product specific and analytical support needs

- **Large, comprehensive equipment set** across testing and analytical services coupled with ongoing investment to address changing technological trends

- **Strong integrated approach** with Failure Analysis and Debug tied to ATE test, Reliability, ESD and Materials Characterizations to quickly and comprehensively develop solutions

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